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The Distribution, Swimming, Cardiac and Scaphognathite Activities at Daytime and Those at Nighttime of the Pink shrimp (*Pandalus borealis*) in the Laboratory

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Abstract

In order to study the difference of the activity of pink shrimp (*Pandalus borealis*) between day and night, the numbers of swimming and resting shrimps were counted and the cardiac and scaphognathite activities were measured by the impedance method.

The ratio of numbers of swimming shrimp to total numbers of shrimp at nighttime were higher than that at daytime. The movement, the cardiac and scaphognathite activities of small shrimp at nighttime were higher than those at daytime.

I. INTRODUCTION

The pink shrimp (*Pandalus borealis*) fishery is one of the most important fisheries in the North Pacific (Davis 1982). Though pink shrimp are usually captured by trawls that were fished on the bottom, some evidences have been given that this pandalid undergoes a diel vertical migration. A diel vertical migration of pink shrimp would have some interesting potential applications in commercial fishing. Foremost is the possibility of harvesting these shrimps by nighttime midwater trawling over untrawlable bottoms (Barr, 1970). There is some evidence that diurnal vertical migration occur (Allen, 1959). The apparent length of time that they were off bottom was directly related to the length of the night (Barr, 1970).

This work is to present the method and the approach of analysis of laboratory studies about activities of the shrimp at day and night time. We observed the behavior such as the swimming rate and the movement in the experimental tank to study the diurnal activity, and measured the cardiac and scaphognathite activities to study the physiological aspect.

II. MATERIAL and METHOD

Experiments were carried out from December, 1979 to January, 1980 at Seward Marine Station, University of Alaska.

Pink shrimps were caught at Cook inlet near Homer in October 16, 1979. These shrimps were cultured in two cubical tanks ($1.0 \times 1.0 \times 1.0$ in height, meter). The light

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in the experimental room was continued on. These tanks were covered by black polyethlene sheets, so the light intensity in tank was constant. Nets of 5 mm meshes (square measure) were placed at four sides of these tanks without bottoms.

The swimming rate was conducted by the ratio of numbers of swimming shrimp to the total numbers of shrimp in the tank. The observation were carried out between 10 : 00 and 11 : 00 at daytime and between 22 : 00 and 23 : 00 at nighttime. We counted each numbers of swimming and resting shrimp from the slit of the polyethlene sheets. The light intensity in these tanks was 10–20 lux all day long. The shrimps were fed on chopped herring meat twice a week at the end of the daytime observation.

The water temperature in the tanks were controlled at $8^{\circ} \pm 0.5^{\circ}C$ and $5^{\circ} \pm 0.5^{\circ}C$ as shown in Fig. 1. Total numbers of shrimp in the tank were 87 at 8°C and 50 at 5°C. The change of the swimming rate and the movement in a day were observed at every three hours from 23 to 24 and from 30 to 31 on December (Fig. 2).

To study the detail movement individually, we observed the movement and position of shrimps in the experimental tank as shown in Fig. 3 ($170 \times 50 \times 30$ in height, cm). Five shrimps were placed in this tank and the distribution and the movement were observed for 30 minutes. The light intensity was 500–600 lux on the water surface all day long and the water temperature was controlled at $8 \pm 0.5^{\circ}C$. The activity and the movement were ruled in the following manner. When a shrimp was swimming at the start and/or at the end of the observation for one minute, the point was 3; and when a shrimp was crawling on the bottom, the point 2. When a shrimp has moved three blocks (one block is 10×10 cm) within 30 minutes, the point was 2; for two blocks, 1; and for over the fence in the tank was 2. The activity rate was determined as the total of these points. The observation was conducted simultaneously with the experiment of the swimming rate. The carapace length, total length and body weight of shrimps are shown in Fig. 4.

The cardiac and scaphognathite activities were measured as physiological aspect. The scaphognathite activity of pink shrimp in the glass vessel ($40 \times 20 \times 30$ in height, cm) was counted. Five shrimps were placed in this vessel and the scaphognathite activity was monitored through the glass at the side wall. The elapsed time of 10 beats was measured with a stopwatch. These measurements were monitored five times in each block. This measurement was also conducted with the experiment of the swimming rate. The carapace length, total length and body weight of shrimps are shown in Fig. 5.

The cardiac and scaphognathite activities were also monitored by the method of Dyer and Uglow (1977). We made two small holes in the carapace of these shrimps. Two stainless steel electrodes were glued to the carapace with a cyanoacrylate glue. One was to measure the heartbeat rate and the other was to measure the scaphognathite activity. Electrodes were connected to an impedance converter (Nihon-Kouden, Inc) which generated a low intensity alternating field across the electrode and the common ground. Impedance between the electrode and the common ground

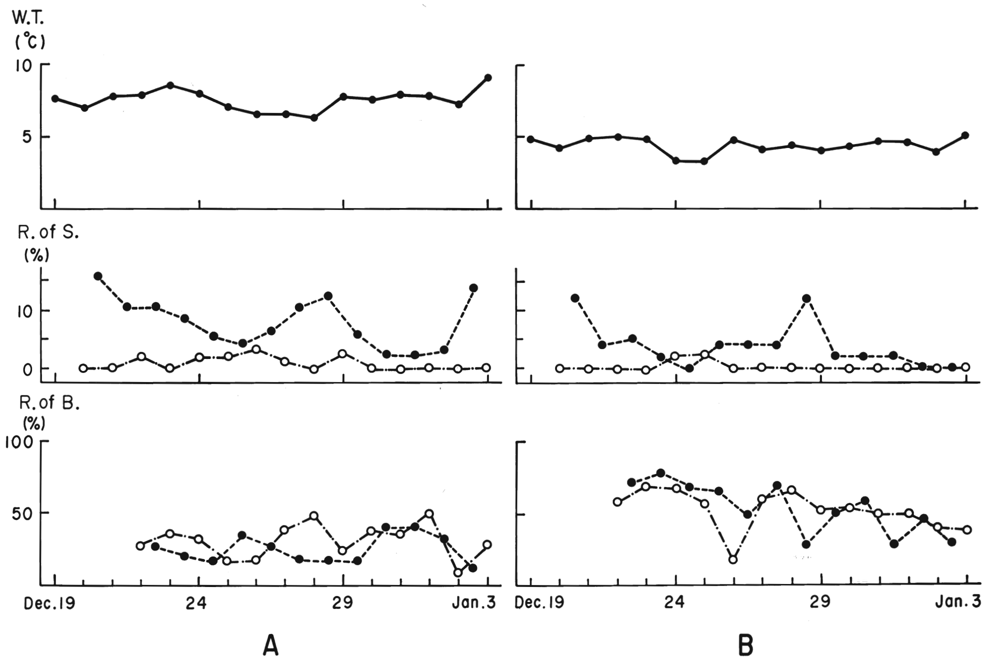

Fig. 1. The swimming rate (R. of S.) and the ratio of shrimp on the bottom of the tank (R. of B.) at the daytime and the nighttime. A···n=87, B···n=50, ○···at the daytime, ●···at the nighttime

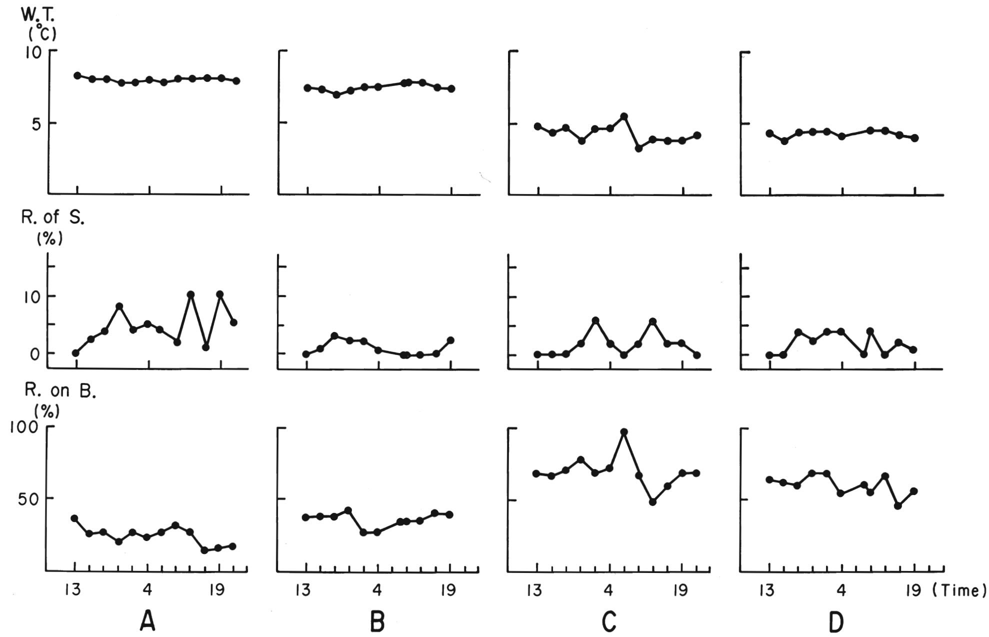

Fig. 2. The daily change of the swimming rate (R. of S.) and the ratio of shrimps on the bottom of the tank (R. on B.). A and C···from December 23 to 24, B and D···from December 30 to 31

was changed by the movement of the cardiac or scaphognathite activities. These changes were recorded on the CRT to monitor the heartbeat rate and the scaphognathite activity. These shrimps with two electrodes could remain alive normally more than one month, so the effect of the electrode does not seem so serious.

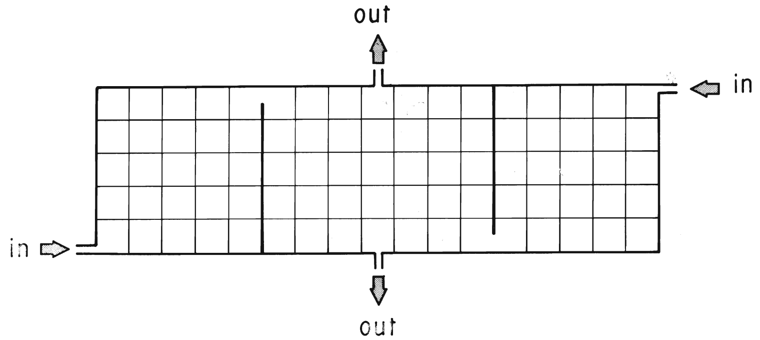

Fig. 3. The tank of the measuring the activity of shirmps (170×50×30 cm in height). IN···sea water in, OUT···sea water out

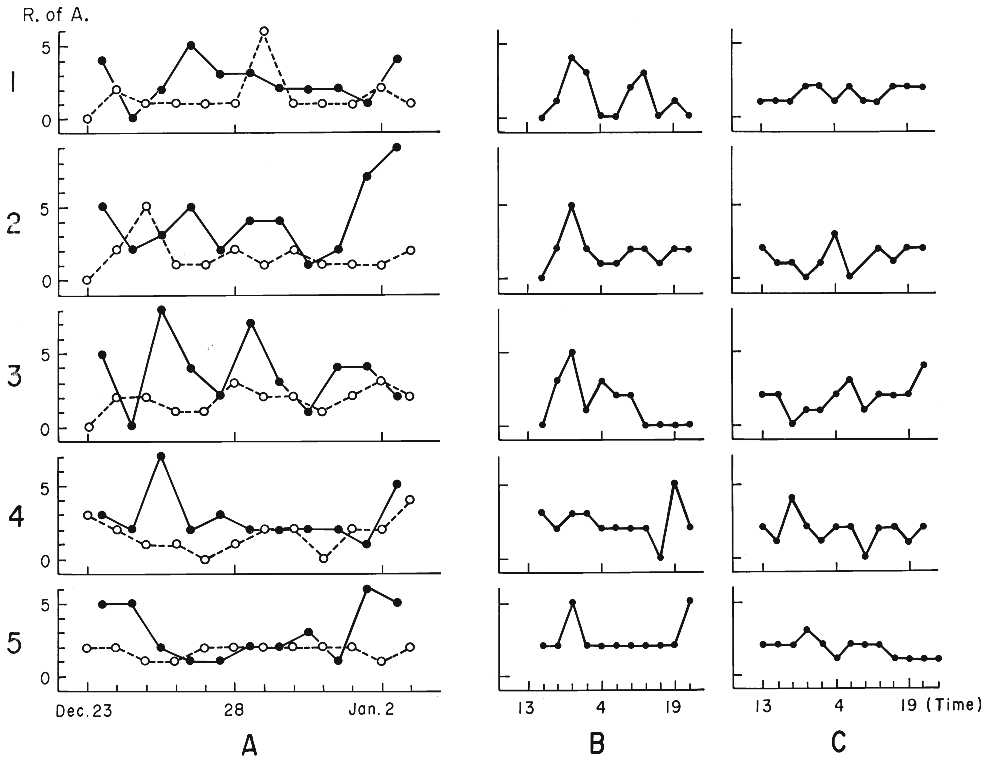

Fig. 4. The rate of activity of pink shrimp (R. of A.) in the experimental tank. A: ○···at the daytime, ●···at the nighttime, B: from December 23 to 24, C: from December 30 to 31

No.	C. L. (cm)	T. L. (cm)	B. W. (g)		No.	C. L. (cm)	T. L. (cm)	B. W. (g)	
1	1.45	5.28	1.65	male	2	1.81	6.95	3.65	male
3	1.75	6.23	3.1	female	4	1.95	6.97	4.1	female
5	2.23	8.2	7.1	female					

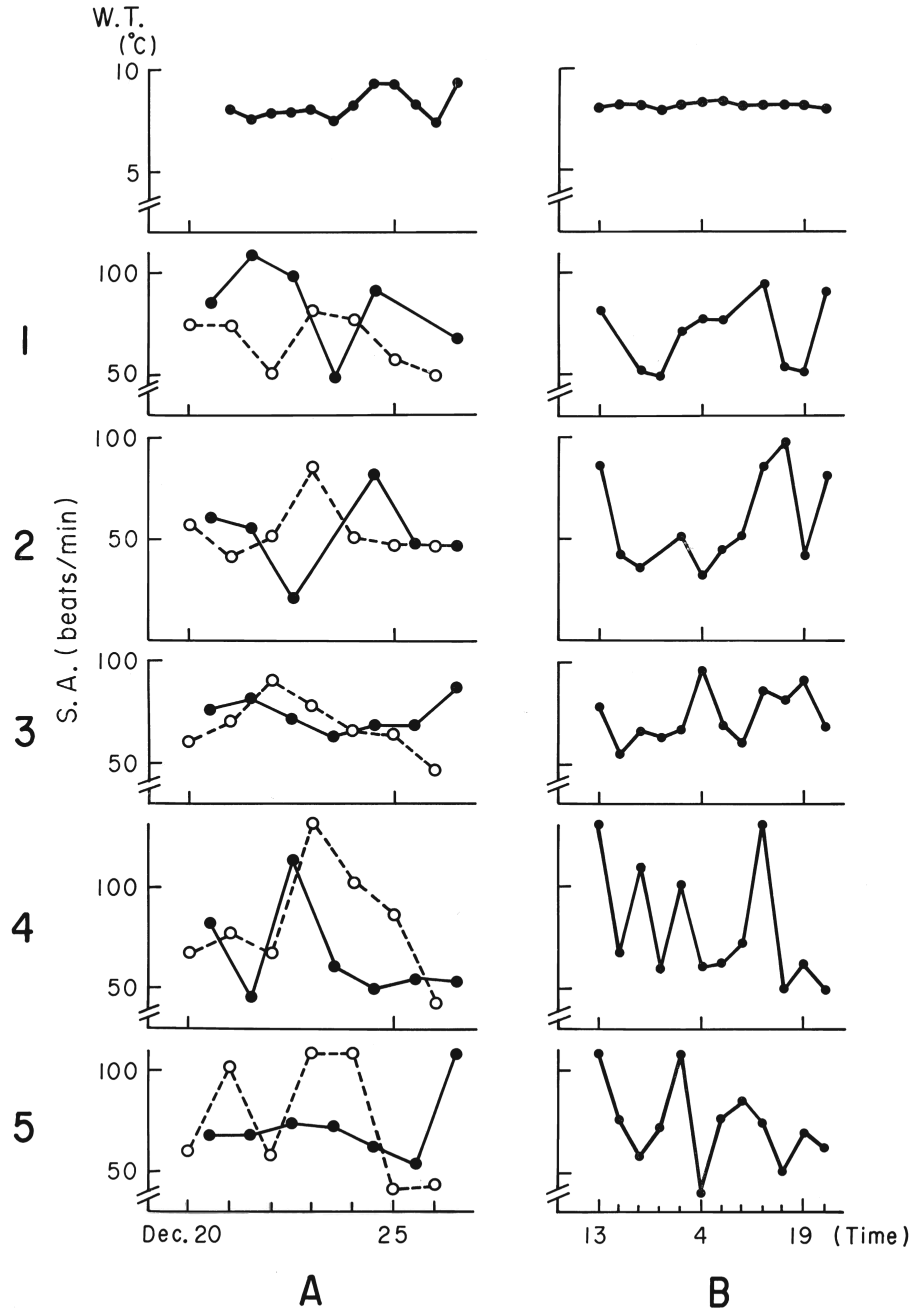

Fig. 5. The scaphognathite activity (S. A.) without the electorede. A: ○…at the daytime, ●…at the nighttime. B: from December 23 to 24.

No.	C. L. (cm)	T. L. (cm)	B. W. (g)		No.	C. L. (cm)	T. L. (cm)	B. W. (g)	
1	1.5	5.9	2.5	male	2	1.7	6.4	3.1	male
3	2.1	7.7	7.0	female	4	1.9	7.3	5.7	female
5	2.4	8.4	8.0	female					

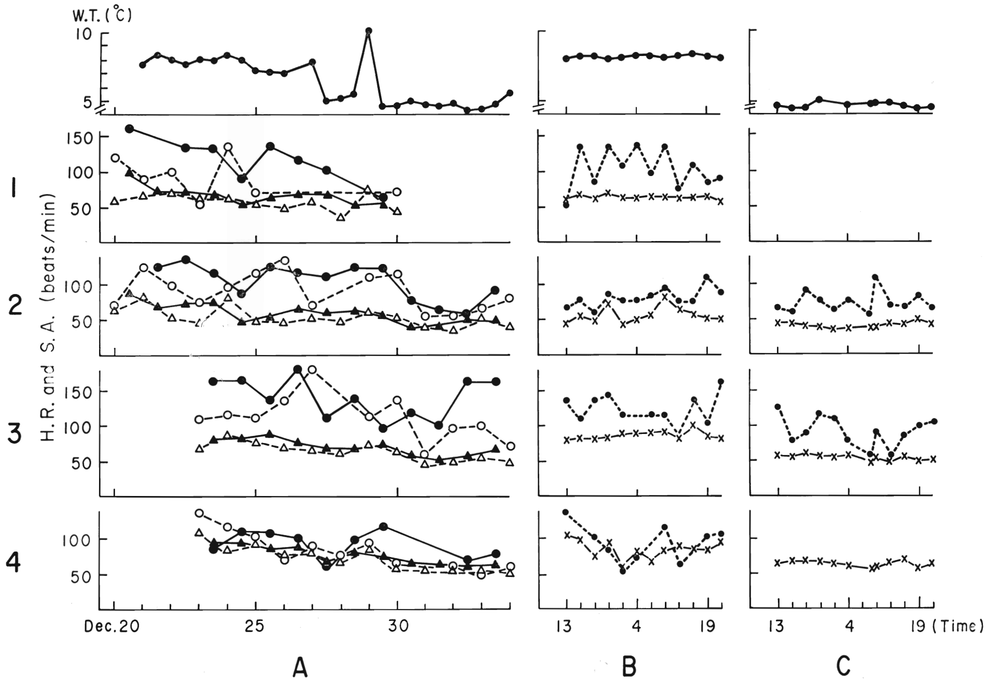

Fig. 6. The scaphognathite activity (S. A.) and the heart rate (H. R.).
A: △···H. R. at the daytime ▲···H. R. at the nighttime
○···S. A. at the daytime ●···S. A. at the nighttime
B: from December 23 to 24, C: from December 30 to 31.
solid line···H. R., broken line···S. A.

No.	C. L. (cm)	T. L. (cm)	B. W. (g)		No.	C. L. (cm)	T. L. (cm)	B. W. (g)	
1	2.2	8.0	6.3	male	2	2.3	8.1	7.2	—
3	2.2	8.1	7.1	female	4	1.9	7.2	4.0	female

These shrimps were placed in a net cage (20×5×15 in height, cm) and this net was placed in a tank (50×50×30 in height, cm). The elapsed time of 10 beats was measured with a stopwatch. These movements were monitored five times in each block. The light intensity was 100–200 lux on the water surface. The experiment was conducted at the same time with the experiment of the swimming rate.

III. Result

The ratio of numbers of swimming and resting shrimp to the total numbers of shrimp in the tank are shown in Fig. 1.

At 8°C, the ratio of swimming shimp were 5–15% at nighttime and 0–3% at daytime. These ratios at nighttime were higher than those at daytime. The ratios of resting shrimp on the bottom were 10–45%. Ratios of resting shrimp on the bottom was slightly different at daytime from that at nighttime.

At 5°C, the ratios of swimming shrimp were 0–12%. At daytime, this ratio was usually 0%, except on two observations at December 24 and 25. These ratios at nighttime were higher than those at daytime. The ratio of resting shrimp on the

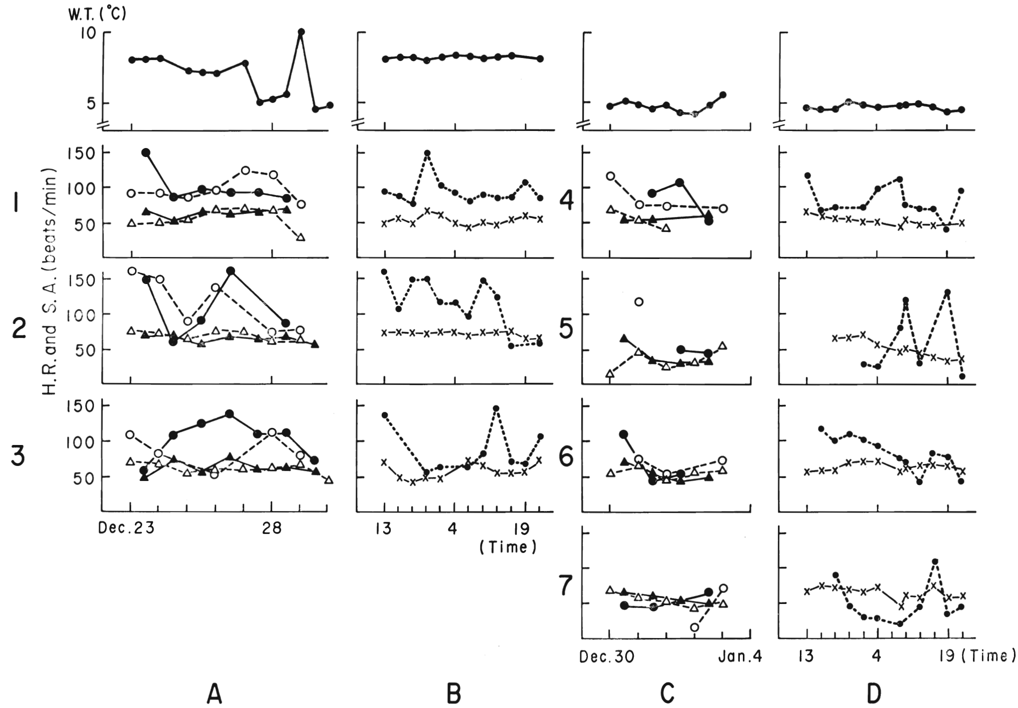

Fig. 7. The scaphognathite activity (S. A.) and the heart rate (H. R.). A and C···from December 23 to 24, B and C···from December 30 to 31.

A and C: △···H. R. at the daytime ▲···H. R. at the nighttime

○···S. A. at the daytime ●···S. A. at the nighttime

B and D: solid line···H. R., broken line···S. A.

No.	C. L. (cm)	T. L. (cm)	B. W. (g)		No.	C. L. (cm)	T. L. (cm)	B. W. (g)	
1	2.3	8.6	9.3	female	2	2.3	7.5	6.0	male
3	2.2	7.3	4.7	female	4	2.3	8.3	7.4	female
5	2.1	7.4	5.2	female	6	1.7	7.0	3.8	male
7	2.1	7.3	5.0	female					

bottom at daytime was not different from that at night time.

These activities of three hours-interval all through the day are shown in Fig. 2. During this experiment, the sunset was at about 4 PM and the sunrise was at about 9 AM but the difference of ratio of swimming and resting between day and night time was not so clear due to a large fractuation of data.

The distribution and movement of shrimp in the experimental tank are shown in Fig. 4. Though this method took a subjective view of the counting, this measurement was one method to indentify the difference of activity individually between day and night time. Activities at nighttime were higher than those at daytime; the shrimps were usually resting at daytime and some shrimps were swimming or crawing at nighttime. In the observation of three-hour intervals all through the day, these ratios at nighttime were also higher than those at daytime (Fig. 4–B, C).

Scaphognathite activities without the application of electrode were 50–100 beats/min (Fig. 5). The difference between the scaphognathite activity at nighttime and daytime might not vary considerably. Scaphognathite activities with electrodes were 60–140 beats/min, and heartbeat rates were 50–80 beats/min (Fig. 6). The scaphognathite activity with the electrode was higher than that without electrode. The heartbeat rate and the scaphognathite activity at nighttime were higher than those at daytime. In the observation of three-hour intervals all through the day (Fig. 5–B and Fig. 6–B, C), these differences were not so clear.

IV. Discussion

Though the experimental materials were kept in tanks for 60 days to the beginning of the experiment, the ratio of the swimming shrimp were clear different between day and night time. During this period, the shrimp might have been subjected to various stress through the supplied foods or some other experiment in this laboratory. But it seemed reasonable that these shrimps had the character, active at nighttime and not active at daytime. Ratios of shrimp on the bottom at 5°C (about 50–60%) were larger than that at 8°C (about 20–40%) as shown in Fig. 1. The total number of shrimps at 5°C (50 shrimps) was 5/9 of those at 8°C (87 shrimps), but numbers of resting shrimp on the bottom in each tanks were the same, 20–30 shrimps per 1 m^2. It seemed that there was a density effect on the distribution of pink shrimp on the bottom, so numbers of resting shrimps on the bottom in each tanks might be the same. Each swimming rate was always under 15% and it seems that these shrimps are not so active.

Barr (1970) showed that the upward shift of catches was even apparent in the

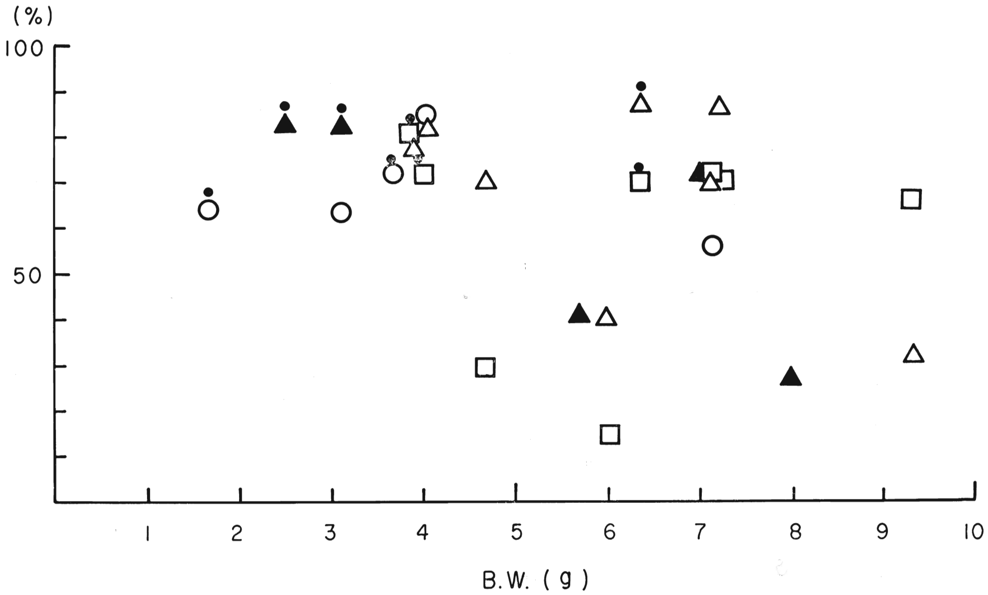

Fig. 8. The relationship between the body weight and the ratio of the numbers of points at the nighttime that were upper from the points at the each sides at the daytime. ○···the movement (from Fig. 4), △···S. A. (from Fig. 5), ▲···S. A. (from Fig. 6 and 7), □···H. R. (from Fig. 6 and 7), ●··· male.

6 PM to 9 PM interval in August, when sunset occurred less than an hour before the pots were pulled. Catches at the upper two levels in the water column decreased or ceased during the interval including sunrise or the next later interval. But in this observation, it is not so clear that the difference between the distribution, swimming, cardiac and scaphognathite activities at daytime and those at nighttime.

The ratio of activities at nighttime that were higher than activities at daytime in the same day and the next day to the activities at nighttime that were lower than activities at daytime in the same and the next day were shown in Fig. 7. The distribution, swimming, cardiac and scaphognathite activities of the smaller shrimps as shown in Figs. 4, 5, 6 and 7 (body weights were under 4 g) were more active at nighttime than those of larger shrimps. Barr (1970) showed that larvae and small pink shrimp were taken at every level, but the proportion of small shrimp was usually much greater in catches from above bottom than in those from the bottom. The activity of smaller pink shrimp in the field seemed to be higher than those of larger pink shrimps. In this experiment, it was also studies in the laboratory that activities of smaller pink shrimps were higher than those of larger shrimps.

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Pink shrimp の行動・心拍・呼吸運動の昼夜による差

中西　孝・西山　恒夫

実験室内における Pink shrimp の昼夜による活発さの度合を調べるため，昼間と夜間に，(1)飼育水槽中の遊泳個体数の計測，(2)実験水槽中の行動，(3)インピーダンス計と目視による心拍・呼吸運動の計測を行なった.

その結果，(1)夜間に遊泳する個体数は昼間より多い，(2)実験水槽中の行動は夜間に活発である，(3)心拍・呼吸運動の昼夜による差異は小さい，(4)小型個体の夜間における活発さの度合は大型個体より大きいことなどが明らかになった.